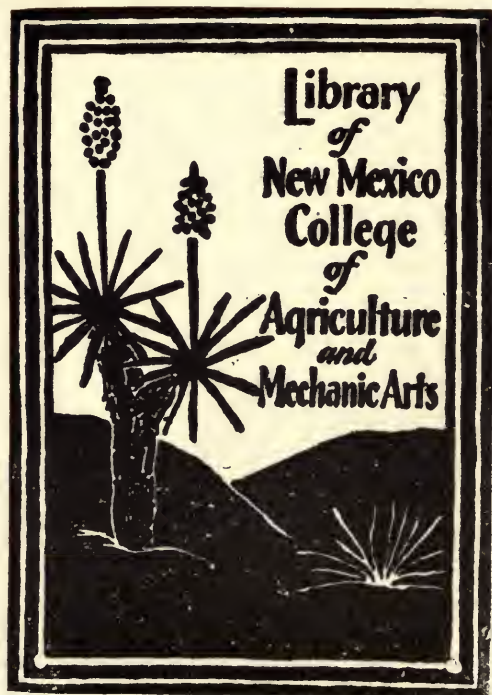


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UNIVERSITY OF ILLINOIS, Agricultural Experiment Station.

BULLETIN No. 2.

ENSILAGE.

Reported by THOMAS J. HUNT, Assistant Agriculturist.

Champaign, August, 1888.

The report herein detailed is a record such, for the most part, as any farmer having a silo might make; and, as such, it is published for the benefit of those who, having had no experience with ensilage, desire to obtain information concerning a material now so much discussed.

THE SILO.

The silo used consisted of a room 11 feet 8 inches x 16 feet x 9 feet high, in the basement of the South barn, on the University farm. One side wall was stone; the other walls were brick. One wall contained two windows three feet square, and the room had a door-way. These were made tight by means of boards. The walls of this room were raised five feet higher by means of studding and flooring, making the silo fourteen feet deep. The floor and the walls of stone and brick were cemented, and a tight joint was made with cement between these and the boards above.

FILLING SILO.

The filling the silo was practically continuous, and was done in three days, August 20-22, 1887, with 54,525 pounds, twenty-seven and a quarter tons, of green corn.

About twenty tons of this consisted of a medium sized, fairly early yellow dent corn (Murdock), which had been planted May 4-6, in rows 3 feet 9 inches apart, with two to three kernels dropped every 9 to 12 inches in each row. At the time of cutting, the stalks had well formed

but small ears, the kernels of which had largely passed the milk state, that is, the kernels were mostly glazed. The lower leaves were yellowish, and some had begun to dry. The growth, though not large, was thought satisfactory, considering the long continued and severe drought that had prevailed here. The yield was not more than seven tons of fresh fodder per acre. Seven tons consisted of a large, late maturing yellow dent corn (Leaming), which had been planted May 28, 1887. The kernels were in the milk and the leaves were entirely green. No marked difference was noted between the ensilage from this and that from the other corn.

At the time of filling the silo, 1.07 acres of corn were cut and shocked. October 15th this dry corn-fodder weighed 4,665 pounds, two and one-sixth tons per acre.

The fresh corn-fodder was drawn to the silo about as fast as cut, and was chopped into pieces one to two inches long by means of a No. 4 Belle City feed cutter, run by a J. I. Case two-horse tread-power. By this means two men with a team could cut two tons of green fodder an hour, although but about one ton an hour was cut on an average. Two men cut the fodder in the field; and two men, each with a team and wagon, hauled it to the barn, the round trip being three-quarters of a mile. One man distributed and packed the material in the silo.

In unloading the fodder, a doubled rope was fastened to the sides of the rear end of the rack-bed and was laid on the bottom of the rack, the middle projecting over the front of the rack. Another rope was attached to a beam above the drive-way. When a load was drawn in, the suspended rope was hooked to the rope on the wagon and the wagon drawn ahead, rolling the load upon the floor. Care is necessary to prevent breaking the rack. This simple device, adopted from Mr. Cushman, formerly a manufacturer of sorghum syrup of this neighborhood, saves much heavy lifting.

Practically, therefore, seven men and three teams in three days filled the silo with twenty-seven tons of corn ensilage. Each farmer may for himself calculate what it would cost him under similar circumstances to fill such a silo. The green fodder, as it came from the feed cutter, fell into the silo, was distributed and tramped with some care. But absolute evenness of distribution was not secured; for a large proportion of the heavier parts, as the corn, remained under the cutter, while the lighter parts, as the leaves, were distributed to the sides of the silo. This is not easily avoided; but care should be taken to prevent it, since it causes unevenness of settling, which seems to prevent the perfect keeping of the ensilage.

CAPACITY OF SILO.

Two days after the silo was filled the contents were covered with tarred building paper, this with two inch plank, and the whole weighted with barrels of sand and other convenient material to the amount, approximately, of fifty pounds to the square foot. Between this time and March

10, 1888, when the silo was opened, the top sank three and one-half feet, or one-fourth the total height. When put in, twenty-one pounds of the green corn occupied a cubic foot. Not allowing for evaporation, the ensilage, when taken out, would weigh twenty-eight pounds to the cubic foot. As shown further on, forty-two pounds of corn ensilage were eaten daily by animals weighing on an average 895 pounds. A capacity of two cubic feet a day for each animal would make a silo sufficiently large, when such animals are to be fed all the ensilage they will eat. If other food is to be given, a less capacity would suffice, no allowance being made for waste. Taking everything into consideration, probably a capacity of two cubic feet a day for each animal is the best basis for estimating the size of the silo.

CONDITION OF THE ENSILAGE.

The silo was opened March 10, 1888, six and one-half months after it was filled. The larger part of the ensilage was well preserved. It was of a brownish color, with here and there streaks and patches of white mould. It had a pleasant odor and an acid taste.

The ensilage of the first foot and that of twelve to fourteen inches on the sides and somewhat more in the corners was rotten, except against the door and the windows above mentioned. Against these places about two inches were rotten. The ensilage was not rotten on the bottom.

Particular attention is called to the fact of the better preservation next the boards. It has an important bearing on the construction of the silo, and would seem to indicate that boards are better adapted to this purpose than stone, brick, concrete, etc., apparently because boards are a better non-conductor of heat. When the ensilage comes into contact with the cement and the cemented surface of the stone and the brick, the heat generated by fermentation is conducted away so rapidly that the temperature does not rise to the height necessary to prevent the development of the organisms of putrefaction; that is, to prevent rotting; or, perhaps, the temperature does not rise to a height sufficient to cause the best development of the organisms of fermentation and to prevent thereby the development of the organisms of putrefaction. The successful preservation of ensilage may require the development of certain organisms which, by the very fact of their development, retard or prevent the growth of organisms which would be detrimental; just as the successful growth of yeast, and the consequent changes produced in the materials used in the manufacture of beer, retards or prevents the growth of those organisms which would spoil the materials. By excluding the air (free oxygen) so far as possible, we produce conditions favorable to the growth of the organisms of fermentation and unfavorable to putrefaction or rotting. In other words, fermentation takes place in the absence, and putrefaction in the presence, of free oxygen. After the fermentative change has taken place, the resulting material, ensilage, will, when exposed to the open air, keep without rotting a much longer time than the fresh material.

The rotting at the top and sides was a serious loss. If it be assumed that there was a waste of one foot on the top and around the sides, which is below rather than above the quantity, the loss is 674 in 1,960 cubic feet, or more than one-third the entire amount. This was not total loss, for the corn was readily eaten by the hogs. So great a loss must be avoided before the silo can be economically used; and from this limited experience, it would seem that if the silo were made of boards instead of stone or a like good conductor of heat, the loss would be largely avoided.

Prof. Henry, of the Wisconsin Experiment Station, has also arrived at the same conclusion. In the *Breeder's Gazette*, of June 13, 1888, he says:

"Probably very few stone silos will be built in the future, as experience shows that a stone wall chills the ensilage during the curing process and, if it does not seriously injure that portion next to it to a thickness of several inches, it renders it, at least, less palatable than ensilage nearer the middle of the silo. The reason, in my judgment, that the silo has not won more friends in the Eastern States is owing to the common use of stone in its construction. On our Experimental farm at Madison our first silo, built in 1881, was of stone, and our conclusions in regard to ensilage were made up from results obtained from this silo; had we put up a wooden structure, I am confident our results would have been worth vastly more to our people than they have been."

FEEDING ENSILAGE.

Feeding the ensilage was begun March 10, 1888, by mixing it with twice its bulk of dry cut corn-fodder, not corn-stover, which our stock had been chiefly fed during the winter. The cattle soon learned to like the ensilage, and after the first week it was fed without mixing with any other substance and was eaten rather better, on the whole, than corn-fodder had been previously.

Daily weights of ensilage fed to the stock were not taken. From what weighing was done, it is estimated that from March 17th to April 30th, 700 pounds on an average were fed daily. During this time the following cattle were given ensilage:

March 17th to April 30th two aged and five yearling bulls, one heifer and one dry cow were fed ensilage, hay, and grain; eight milch cows, ensilage, straw, and grain; ten dry cows and five heifers, ensilage and straw.

March 17th to April 16th three steers were fed ensilage and corn.

April 13th to 30th four heifers and two dry cows were fed ensilage and hay.

It will thus be seen that for 45 days 37 head were, on an average, fed 700 pounds, about 19 pounds each, daily. Of these 15 had ensilage and straw only; 8 had ensilage and straw with grain, usually four quarts bran added daily; and 9 ensilage hay and grain. All thrived exceedingly well, considering amount of food eaten.

EXPERIMENT WITH HEIFERS.

Five thoroughbred Shorthorn heifers, which had been fed twice daily upon ensilage and straw from March 17th to April 16th, were then weighed and for two weeks were fed three times daily upon ensilage only. The quantity given them was weighed at each feeding, and the amount not eaten was removed and weighed before they were next fed. Their feed boxes were arranged to prevent waste as far as practicable, and what was thrown out was collected and weighed. Here is a chance for error, but the error is a slight one. The heifers were bedded with straw, care being taken to keep it well back out of their reach. Nevertheless a very small quantity was eaten, but not enough it is believed, to affect materially the result. The heifers were kept in a comfortable stable and were turned into a yard during two or three hours daily for water and exercise. During the two weeks, the five heifers were fed 3,331.5 pounds of ensilage, of which 395 pounds were removed from time to time because it was not eaten; or, stated otherwise, they were each given daily on an average, nearly forty-eight pounds of ensilage, of which about six pounds, one-eighth, were not eaten.

The following table gives date of birth, weights, and gain of these animals in the time specified :

NAME.	DATE OF BIRTH.	WEIGHT, APRIL 16.	WEIGHT, APRIL 30.	GAIN, APRIL 16-30.	WEIGHT, MAY 1.	GAIN, APR. 16-MAY 1.
Grace 7th.....	May 26, 1886.....	855	950	95	910	55
Queen Mary 14th.....	June 28, 1886.....	815	860	45	845	30
Duchess of York 21st.....	July 16, 1886.....	880	955	75	945	65
Duchess of York 20th.....	June 29, 1886.....	925	995	70	970	45
Bloomanthe 4th.....	May 13, 1886.....	875	945	70	925	50
Average gain				71.		49

It will be remembered that these heifers had been fed for a month before this experiment, on a moderate allowance of ensilage, about twenty pounds daily, and all the oat straw, of a good quality, they would eat. Obviously, then, at the end of the experiment, during which they had been fed ensilage alone, their stomach contents were unlike what they were at the beginning of the experiment. At the end of the fourteen days the heifers were weighed under the same conditions as at the beginning of the experiment (after morning feed and before watering), and were found to have made an average gain in weight of seventy-one pounds. They were allowed to go without their noon feed, and were

given on the following evening and morning a moderate allowance of ensilage and what hay they would eat, and were then weighed again. This time the average weight was twenty-two pounds less than the previous day, or the average weight was forty-nine pounds more May 1st than April 16th. It is a comparatively easy matter to determine the gain in weight of an animal during a given time. It is quite another matter to determine how much an animal has gained in flesh and fat. Undoubtedly the gain shown at the second weighing comes nearer the actual gain of carcass. There is, doubtless, a grain of reason in the English farmer's objection to the use of scales and his insistence on judging from appearance. Improvement in general condition and appearance, as well as gain in weight, should be considered. Judged in this way the result was also very favorable to the ensilage. The improvement in the general condition of the animals was very decided.

The patent facts of this experiment are that the heifers, after having been fed on a moderate allowance of corn ensilage and all the oat straw they would eat for about four weeks, when given a daily allowance of forty-eight pounds of corn ensilage, consumed about seven-eighths of it only, continued to thrive exceedingly well, and during the two weeks made a very satisfactory gain.

COMPARATIVE CHEMICAL COMPOSITION OF ENSILAGE AND CORN-FODDER.

An analysis of the ensilage, together with analyses of corn-fodder, was made by H. S. Grindley, class of 1888, and the results presented in a thesis for the degree of bachelor of science in the College of Agriculture, University of Illinois. A summary of these results is here presented.

Samples, how taken. Upon opening the silo March 10, 1888, a sample of ensilage several feet from the top (No. 1, in the table below) was taken for analysis. A sample of corn-fodder (No. 2) made from similar corn in the same field, and cut at the same date, was taken November 7th, in order to compare its chemical constituents with those of ensilage. A sample of corn-fodder of another variety of corn (No. 3), which was cut about a month later and remained in the shock for five months, was taken as soon as it came from the field. From a similar sample (No. 4) the corn was removed and the stover taken for analysis. Samples were taken by running a bundle through a feed cutter and mixing on a tight floor.

Method of analysis. The method of analysis was the same in all cases. The several samples were passed through a drug mill and then through a coffee mill, until the material was sufficiently pulverized for analysis. Sample No. 2, when taken from the mow in the barn, was very dry, and it was also pulverized in the laboratory before the amount of moisture was determined. In the other cases the amount of moisture was determined before they were pulverized, by taking 200 to 300 grams of the sample and drying in an air bath at 105° C., until the weight remained constant.

The ash was determined by charing the substance at a low red heat, exhausting the charred mass with water, burning the insoluble residue, adding the ash to the residue from the evaporator of the aqueous extract obtained above, drying the whole at 110° C. and weighing.

The ether extract was determined by taking two grams of the dried substance and exhausting for eight hours with anhydrous ether in a continuous extracting apparatus. The ether extract was then dried at 100° C. in a current of carbonic acid, to a constant weight.

The total nitrogen was determined by the Kjeldahl method. The albuminoid nitrogen was determined by taking one gram of the substance, adding 100 c. c. of water in a beaker, heating to boiling and adding a quantity of the cupric hydrate mixture, prepared according to Stutzer's method, containing .8 gram of the hydrate. The mixture was then stirred thoroughly, filtered when cold and washed with cold water; and, without drying, the filter and its contents were put into concentrated sulphuric acid for determination of the nitrogen by the Kjeldahl method.

Crude fiber was determined by the Weende method; the nitrogen—free extract—by difference.

Chemical composition. The following table gives the percentage of nutrients and acids contained in fresh and dry substance of fodders analyzed:

	No. 1. ENSILAGE.		No. 2. CORN-FODDER		No. 3. CORN-FODDER		No. 4. CORN-STOVER	
	<i>Fresh Substance.</i>	<i>Dry Matter.</i>	<i>Fresh Substance.</i>	<i>Dry Matter.</i>	<i>Fresh Substance.</i>	<i>Dry Matter.</i>	<i>Fresh Substance.</i>	<i>Dry Matter.</i>
Water.....	64.42	....	7.12	....	24.85	....	32.65	....
Albuminoids.....	2.82	7.93	9.76	10.51	6.83	9.09	3.01	4.47
Ether extract.....	1.58	4.45	2.46	2.65	1.65	2.20	1.18	1.62
Nitrogen, free extract.....	22.24	62.52	59.91	64.51	47.81	63.62	30.47	45.25
Crude fiber.....	7.18	20.20	16.39	17.65	14.39	19.15	27.34	40.60
Ash.....	1.74	4.90	4.34	4.68	4.48	5.97	1.74	4.90
Volatile acids.....	.065	.182	....	....	....	....	....	....
Non-volatile acids.....	.035	.098	....	....	....	....	....	....
Total nitrogen.....	.601	1.69	1.838	1.98	1.320	1.77	.505	.75
Albuminoid nitrogen.....	.451	1.268	1.561	1.681	1.092	1.454	.482	.716

Samples No. 1 and No. 2 may be compared to determine the comparative chemical composition of ensilage and corn-fodder.

The analyses show a decrease in the total nitrogen of .29 per cent., or a loss of 14.6 per cent. of the total nitrogen in the fodder. There was a decrease of 2.58 per cent. of albuminods in the total solids, equivalent to a loss of 24.5 per cent. of the total albuminods put in the silo. It will be understood that the albuminoids are indispensable nutrients of any food ration, and are not replaceable by any other class of nutrients. The

loss is in part due to their reduction into amids and other degraded nitrogenous compounds. Thus, while there was only .3 per cent. of non-albuminoid nitrogen in the corn-fodder, there was .4 per cent. in the ensilage. Of the total nitrogen in the corn-fodder, only 15.15 per cent. was in the form of non-albuminoid nitrogen, while in the ensilage there was 25.44 per cent. These degraded forms are supposed to have about the same feeding value as the soluble carbohydrates.

The percentage of soluble carbohydrates (nitrogen, free extract) in the ensilage is less than in the corn-fodder by 2.01 per cent., while the crude fiber is greater by 2.25 per cent.

The ether extract, which contains oil and other extractive matter, is 1.7 per cent. greater in the ensilage than in the corn fodder; or, in other words, the ensilage contains 1.6 times as much as the corn-fodder. This is in part due to the conversion of sugar (glucose) into organic acids which are soluble in ether, while the sugar from which they were formed is insoluble.

The ensilage contains a slightly higher percentage of ash. This is to be expected where there is no drainage, for the fermentation decreases the organic matter.

The fresh ensilage contains .1 per cent. of organic acids. Of this .065 was volatile, and .035 non-volatile. The former is considered acetic and the latter lactic acid.

BIOLOGY OF ENSILAGE.

A good deal has been published from time to time by various persons on the chemistry of ensilage; very little on its biology. Dr. Manly Miles has, however, called attention to this subject in an interesting discussion in the First Annual Report of the Massachusetts State Agricultural Experiment Station, pages 33 to 39. Not much more can be done here than to suggest the possibilities in this direction. By the help and guidance of Prof. T. J. Burrill, of this University, the writer was enabled to make a few observations of the organisms contained in ensilage.

March 13, 1888, bits of ensilage were placed in sterilized bottles with the usual precautions incident to bacteriological investigation. At 3:30 p. m. a small piece of ensilage was put into a test tube containing a strong sterilized solution of commercial glucose. March 24th, 10 a. m., a profuse growth of organisms was apparent. The fluid emitted a strong odor characteristic of ensilage.

Slides were mounted and found to contain two bacterium forms, and possibly a third, closely resembling, if not identical with, *Bacterium aceti* and *Bacterium lactis*. The greater portion of the growth, however, was a *Saccharomyces*, probably *S. Pastorianus*, which is thus described by Prof. Burrill:

"Cells various, from long cylindrical to roundish oval, more of the latter. The long ones are about 2.5 to 3 mikros, 10-100,000 to 12-100,000 in. wide, and some of the joints reach 25. mikros 1-1,000 in. long. The oval cells average about 4 by 6 mikros, but vary from 4 to 8 mikros

in length and 2 to 6 mikros in width. The long ones often have 3 to 5 joints; the ovals, mostly single; sometimes in two. All often budding."

Another sterilized solution of commercial glucose was inoculated with a few drops from the above test tube. This again developed *Bacterium* and *Saccharomyces*, although somewhat less vigorously than before. Another test tube containing glucose solution which had not been inoculated failed to develop any organism.

March 24th some ensilage was again taken from the silo and placed in a sterilized test tubes plugged with cotton with the usual precautions. March 27th there had developed two or three round white masses on a piece of the ensilage. A portion of one of these masses was examined and found to consist of a *Saccharomyces* swarming with bacteria, apparently identical with those developed in the glucose solutions. Cell cultures were made in a drop of glucose solution. A growth of yeast cells was obtained. In this case some of the long jointed, mycelium-like cells were observed. This would indicate that there is a tendency to assume this form in the presence of free oxygen.

From these observations it seems probable that these are the organisms which produce the fermentation in the ensilage, and that the two very distinct forms play an important part in the production of ensilage. The *Saccharomyces*, or yeast, in the absence of air (free oxygen) in the silo, abstracts oxygen from the glucose of the corn, from which alone, it is claimed, yeast can obtain intermolecular oxygen. This is fermentation. By the abstraction of oxygen from glucose it becomes alcohol. If the fermentation stopped here, the ensilage would be sweet; but at this point the bacteria take up the unfinished work and change by degrees the alcohol into acetic, lactic, and possibly other organic acids. It is in this acid, or sour, state that we almost universally find ensilage. At the same time these organisms require nitrogen for their development and in their growth; consequently they decompose nitrogeous compounds and thus decrease the percentage of albuminoid nitrogen, as shown by chemical analysis. There is no reason to suppose, either from the known functions of these organisms or from chemical analysis, that indigestible material is made digestible by their action.

SUMMARY.

The conclusions and results of these experiments may be summarized as follows:

1. The yield was not more than seven tons per acre of green corn, or two and one-sixth tons of corn-fodder.
2. It required seven men and three teams three days to fill the silo with twenty-seven tons of green corn.
3. Difficulty was found in obtaining evenness of distribution in the silo and, consequently, evenness of settling.
4. Twenty-one pounds of green corn occupied a cubic foot when put into the silo and shrunk one-fourth in volume, weighted with fifty pounds to the square foot

5. Size of silo desired may be approximated by allowing two cubic feet a day for each animal.

6. With a silo of stone, brick, and cement the ensilage rotted at the sides and top to the extent of one-third the entire amount.

7. There is evidence for believing that this loss could be considerably obviated by building the silo of wood.

8. Thirty-seven head of cattle, fed forty-five days on a moderate allowance of corn ensilage with other food, ate the ensilage somewhat better than corn-fodder and thrived very satisfactorily.

9. Five yearling Shorthorn heifers, averaging 895 pounds each, were given daily forty-eight pounds of corn ensilage each, ate about seven-eighths of it, and during fifteen days made an average gain of forty-nine pounds each. [See page 19.]

10. Analyses of corn ensilage and corn-fodder made from similar corn show a loss in the ensilage of total nitrogen, albuminoid nitrogen, and soluble carbohydrates and an increased per cent. of non-albuminoid nitrogen, ether extract, crude fiber and ash.

11. The fresh ensilage contained .1 per cent. of organic acids, .065 volatile, and .035 non-volatile.

12. Ensilage was found to contain yeast and bacteria ferments. Neither from a chemical nor from a biological stand-point is there reason for believing that the ensilage is made more digestible by their action.

SELIM H. PEABODY,

President of Board of Direction.

The bulletins of the Station will be sent *free of all charges* "to persons engaged in farming who may request that they be sent."

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